

A TOP DOWN THEORY OF LOGICAL MODELING

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INTRODUCTION

Scientists, logicians, mathematicians, and linguists are among those who employ models. Yet, there are various views of models. For example, Quine has defined models as "a sequence of sets"¹ and van Fraassen sees them as "specific structures, in which all relevant parameters have specific values."² Harré argues that they can be either theoretical, as in a "set of sentences which can be matched with sentences in which the theory is expressed" or iconic, "some real or imagined thing, or process, which behaves similarly to some other thing or process, or in some other way than in its behaviour is similar to it."³ The variation in these definitions reflects the many uses of models. The common ground between these definitions is that a model is an analogy, or a "relationship between two entities, processes, or what you will, which allows inferences to be made about one of the things..."⁴ Traditional models share a mapping function

in which the model and the system it compares stand in an analogical relationship, inviting horizontal comparisons and analysis. Models have been important in the development of logic, especially modal logics.⁵ In science, they are "the ¹very basis of scientific thinking."⁶

Yet, the dangers of such "bottom up" analogical approaches are well known and lurking in the background of any serious discussion about the appropriate use of modeling. The analogy of the system under examination is always an artificial construct. Various competitors rival the model, with success based on the best analogy. Hence, analogy becomes the primary task, and problem. A model is developed through a theory-laden process that involves assumptions about initial conditions and applicable laws. It is hard to separate out those positive areas of the model that are similar to the system under analysis from the

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negative areas that do not correspond to the system. Comparing the properties of the two systems is not enough. Analogical reasoning does not occur in a vacuum. Also, trivial and non-trivial modeling invites difficulties because structural isomorphism is not enough to account for similarity. There may be an endless number of systems that exhibit similarity. Then, of major concern, the appearance of possible counterfactuals may doom the modeling enterprise.⁷

But modeling is vital, often indispensable. Modeling can help provide knowledge not directly accessible in the real world. For instance, some models may provide a powerful even superior, substitute for reality. Theordoric of Freibourg's famous use of glass globes to simulate the role of raindrops in the formation of a rainbow show that models may provide the only possible means of studying an otherwise unresearchable process.⁸

TYPE THEORY MODELING

In this short paper I will argue for a top down theory of modeling, as presented by Aronson, Harré, and Way. In this view, "theories are

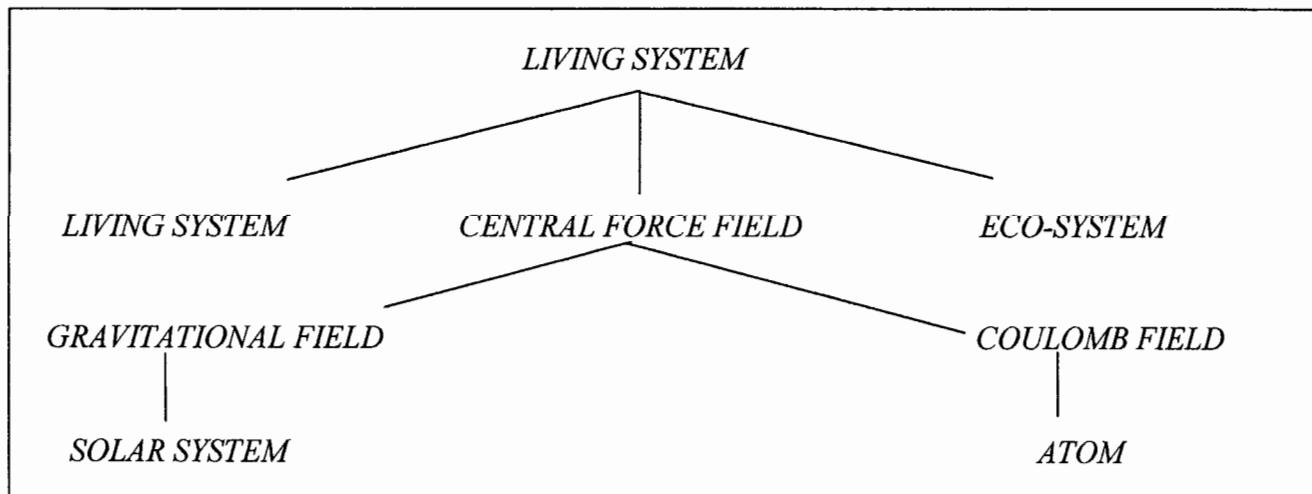
not thought of in terms of the hypothetico-deductive structure. Instead...theories are thought of as essentially involving chunks of type-hierarchies..."⁹ If this is so, then theory-laden models already have types imbedded within the theoretic framework. Often, the type provides the direction, cohesion, and focus of the theoretical construct. So the types are already there within the theory. They simply have to be identified and used.

In the traditional comparison theory of bottom up modeling, a potential model is examined against the actual world, whether the real world is viewed logically, linguistically, or scientifically. The model functions to emulate or duplicate aspects of the real world, if not completely picture it. Because the bottom up model is not the actual world, but merely a representation, it may be locked into a deductive structure that is less elastic than the real world. This allows for avoidable difficulties in discussing possible worlds. The bottom up model also may generate counterfactuals that are known not to be true in the real world.

However, for Aronson, Harré, and Way, theories are descriptions of families of models

that are metaphysical devices for expressing the ontology of our world. Our understanding of the real world is theory-laden, and therefore bottom up modeling invites comparisons which are problematic from the beginning, inherently damaged by a search for similarity that may tell us little about the actual world. Rather, they argue that the theoretic nature of our ontology must be recognized and accepted. If so, then we must look at what theories share in common. Often, a model and the system it attempts to emulate are sub-types of a larger type. The larger type is a concept that is the genesis of many ways of looking at the world. This larger type can function as a source from which hierarchies may be generated.

On this top down view, type theory becomes crucial for modeling. Type identification and analysis are prior to any comparison of models. By correctly identifying the larger type or class for examination, models are generated from the type itself. For example, if one wanted to ask if the solar system is "like an atom," one must recognize that the type under discussion is a notion of a complex system. Therefore, if a solar system is a complex system and an atom is a complex system, then the question is answered, not by comparison of the two, but through an inherited relationship that is found in any complex system. The following diagram illustrates the inheritance of relationships from the type at the top.¹⁰



The structure of the hierarchy generates the similarity, which is the answer to the question about the atom and the solar system. Given the view that both are complex systems, then the solar system is like an atom. The inheritance of the relationship is the vital factor in answering the question. The top down theory presents a modeling system and a system being modeled as "the lowest subtypes in a hierarchy."¹¹ The explaining theory incorporates them both.

Of course, the weakness of this top down view is the difficulty in identifying the proper type for discussion. The focus of modeling would shift to this issue. But the type-hierarchy model is a recognition of advances in the generation of appropriate paradigms for scientific research and a sophisticated use of modal logic.¹² The use of a type-hierarchy model can help to filter positive from negative analogies in a non-arbitrary manner. Similarity is a derived relationship. Counterfactuals based on analogy are side-stepped, thereby becoming benign. Analysis is primarily a function of classification.¹³

CROSS-DISCIPLINARY DISCOURSE

The top down theory was extensively

analyzed in two conferences on cross-disciplinary discourse in 2001 and 2002. Sponsored by the Physical Science Laboratory at New Mexico State University, these conferences brought together scholars from a variety of disciplines, from literature, history of science, mathematics, biology, philosophy, robotics, computer sciences, psychology, logic, and linguistics. Each speaker discussed current issues and uses of methodology within a discipline, and then attempted to visualize cross-disciplinary applications of other methodologies. For example, Stuart Kauffman from Bios Group discussed the application of complex systems in biology and logical consistency. Dan Rothbart from George Mason University examined various uses of scientific instrumentation in the development of new methodologies. Michael Apter of Georgetown University presented his findings in reversal theory as relevant to both psychology and decision theory. Luis Arata of Quinnipiac University outlined a cross-disciplinary approach between literature and philosophy. A total of 44 papers were presented at these two conferences. A third conference will be held in January, 2003. A new journal, the *Journal of Models and*

Modeling, will showcase papers from these conferences.

Based on discussions at these conferences, there seem to be many ways to visualize cross-disciplinary modeling. One possible way to construct cross-disciplinary models is on the second-order level. This is where a top down theory could be most helpful. Consider the case of someone trying to forge a common model from sociology and physics. The search for similarity is the basis of most modeling. A category could be selected as the starting point of a top down approach, allowing for the construction of a type hierarchy. Second order levels and higher levels are accommodated by such an approach, as the hierarchy simply expands downward. On the meta-level, a top down theory demands attention to such concepts as

"category", "type", "similarity", and "inheritance". The philosophical debate about these concepts will actually add to the discussion, showing new ways to find commonality or to pass down inheritance. Logic and mathematics emerge as even stronger candidates for the structure and language of models.

CONCLUSIONS

1. In a top down view of modeling horizontal analogical comparisons are eliminated.
2. Commonalities between type-hierarchies are inherited relationships.
3. The relevant focus for discussion of models becomes the shared or unshared type that generates or fails to generate two or more models.

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² Bas C. van Fraassen, *The Scientific Image*, Clarendon Press, 1980, p. 44. [For an extension of this view to modal logic, see Graeme Forbes, *The Metaphysics of Modality*, Clarendon Press, 1985, pp. 7-8.]

³ Rom Harré, *The Philosophies of Science*, Oxford University Press, Second Edition, 1985, pp. 173-4.

⁴ *Ibid.*, p. 172.

⁵ "Each possible world can be thought of as being essentially a model for the original non-modal language ..." Graeme Forbes, *Languages of Possibility*, Basil Blackwell, 1989, p. 2.

⁶ *Ibid.*, p. 174.

⁷ David Lewis, *Counterfactuals*, Harvard University Press, 1973, and Saul Kripke, *Naming and Necessity*, Harvard University Press, 1972, especially pp. 16-20.

⁸ Rom Harré, *Great Scientific Experiments*, Oxford University Press, 1983, pp. 84-94.

⁹ Jerry L. Aronson, Rom Harré, and Eileen Way, *Realism Rescued: How Scientific Progress Is Possible*, Open Court Press, 1995, p. 88.

¹⁰ The diagram is taken from *ibid*, p. 109.

¹¹ *Ibid.*, p. 110.

¹² Rom Harré, *Varieties of Realism*, Basil Blackwell, 1986, pp. 317-343.

¹³ Bertrand Russell, "Mathematical Logic as Based on a Theory of Types," *American Journal of Mathematics*, 1908, Volume 30, pp. 222-262, and Alfred North Whitehead and Bertrand Russell, *Principia Mathematica*, Volume I, Second Edition, Cambridge University Press, 1927, pp. 37-65. Also, see my "Ryle's Debt to Russell," *Linacre Journal*, 1999, Number 3, pp. 55-69.